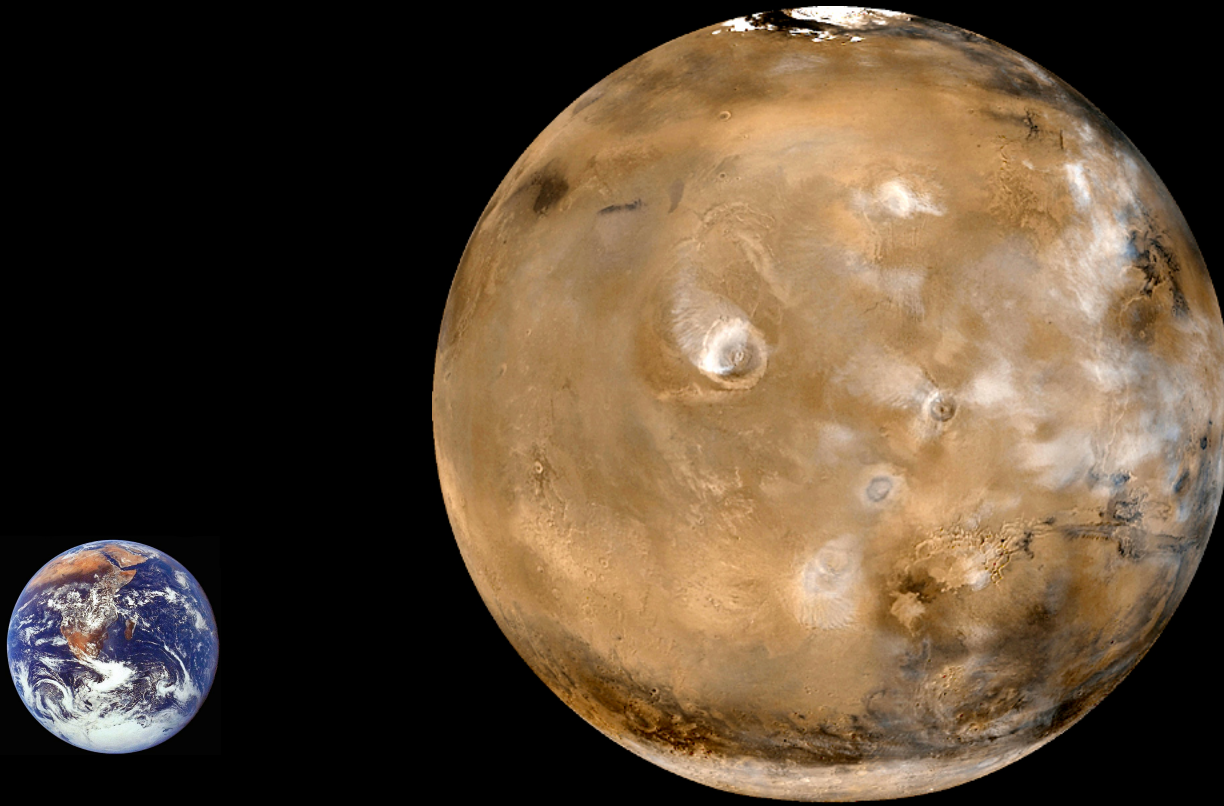


Potential Habitability and Biosignature Preservation at the Nili Trough Site

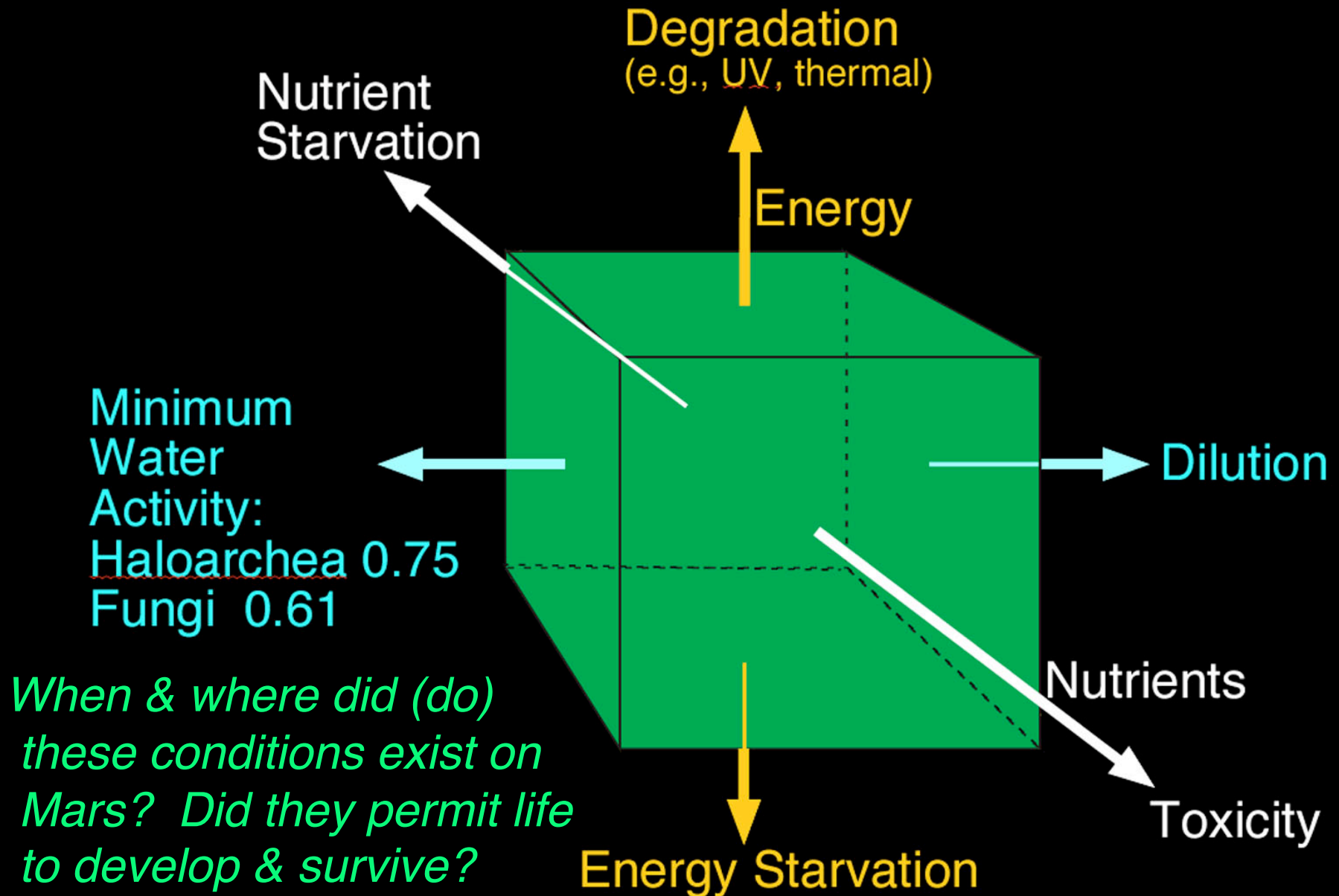


David J. Des Marais
NASA, Ames Research Center, Moffett Field, CA

Key Factors Affecting Astrobiology Potential

- Diversity and geologic context
 - Habitable conditions sometime in past
 - Diversity of habitable environments
 - Duration of habitable conditions
- Preservation of key evidence
- Accessible by MSL rover

Range of Conditions that Sustains Life



Thriving in Darkness

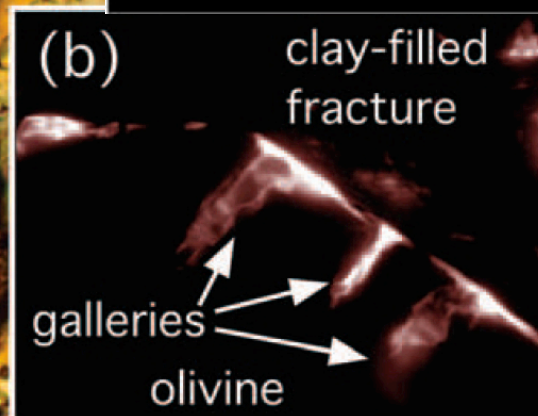
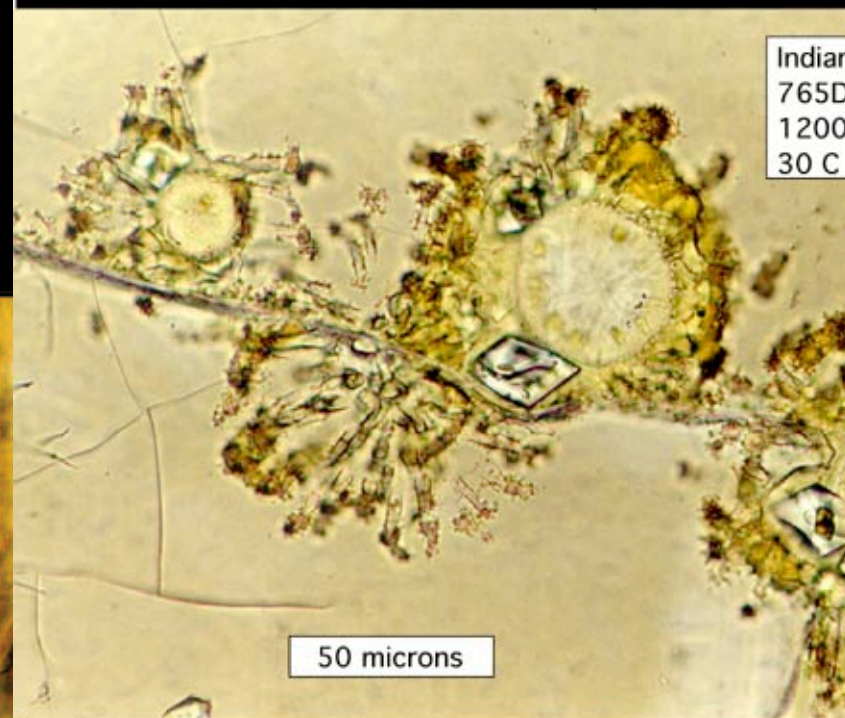
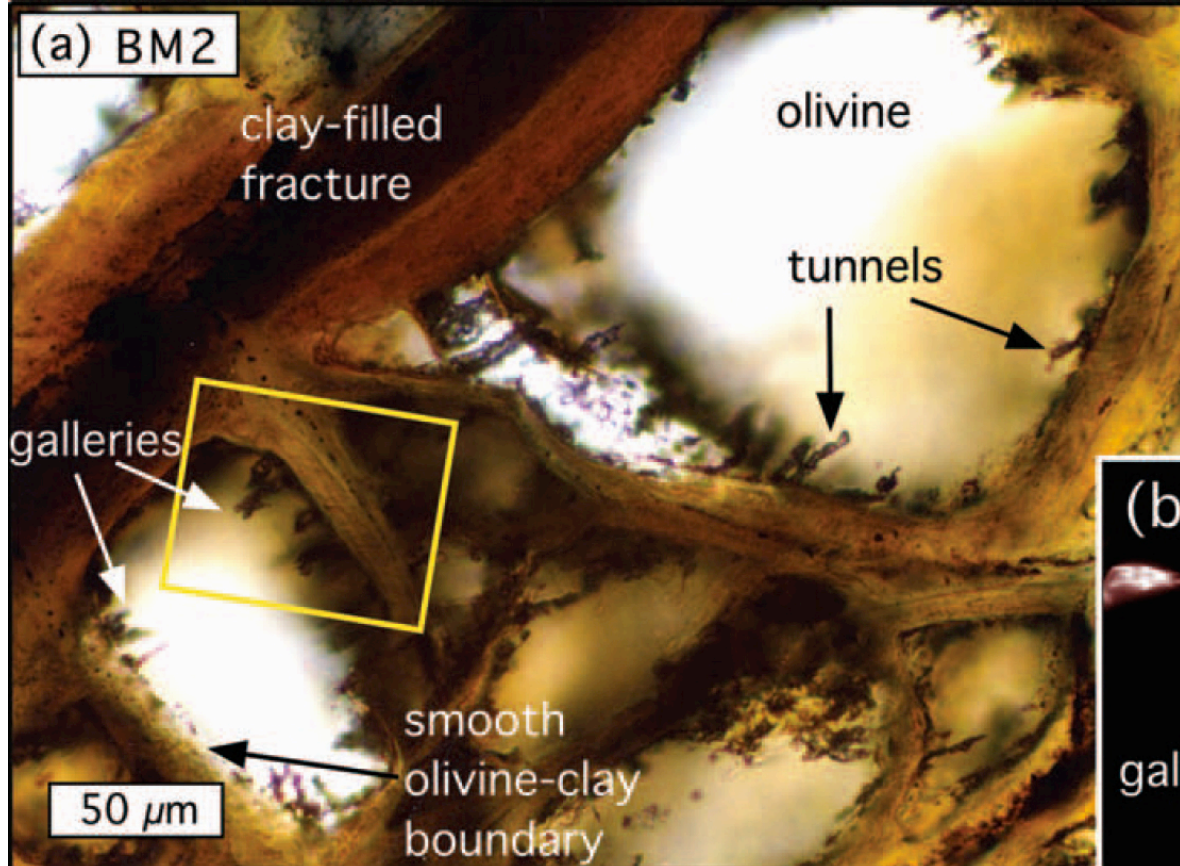
Oxidation-reduction reactions can sustain life, even without photosynthesis (and without O_2)

Oxidants: O_2 ; CO_2 ; minerals/fluids with SO_x , Fe^{3+} , NO_x , etc.

Reductants: H_2 ; C_{red} ; minerals/fluids with S_{red} , NH_4^+ , Fe^{2+} or other reduced species

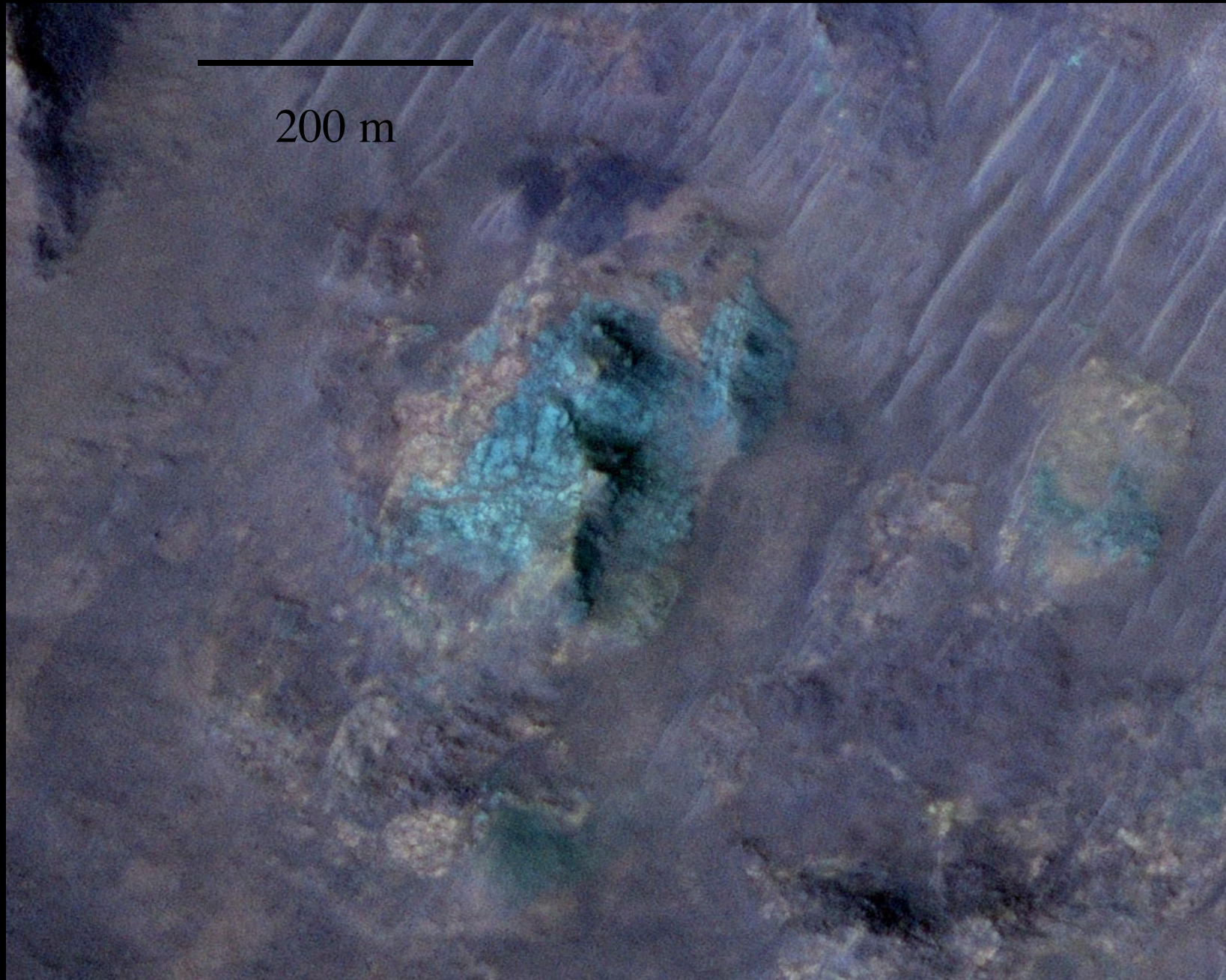
Minerals must be identified comprehensively and definitively to search for potential habitats and life

Indian Ocean basalt
1200 m below sea floor
(M. Fisk)



Oregon dunite with microbes in galleries (Fisk et al., 2006)

Nili Fossae: Mafic source rock and altered product



Long-Term Sustainability of a High-Energy, Low-Diversity Crustal Biome

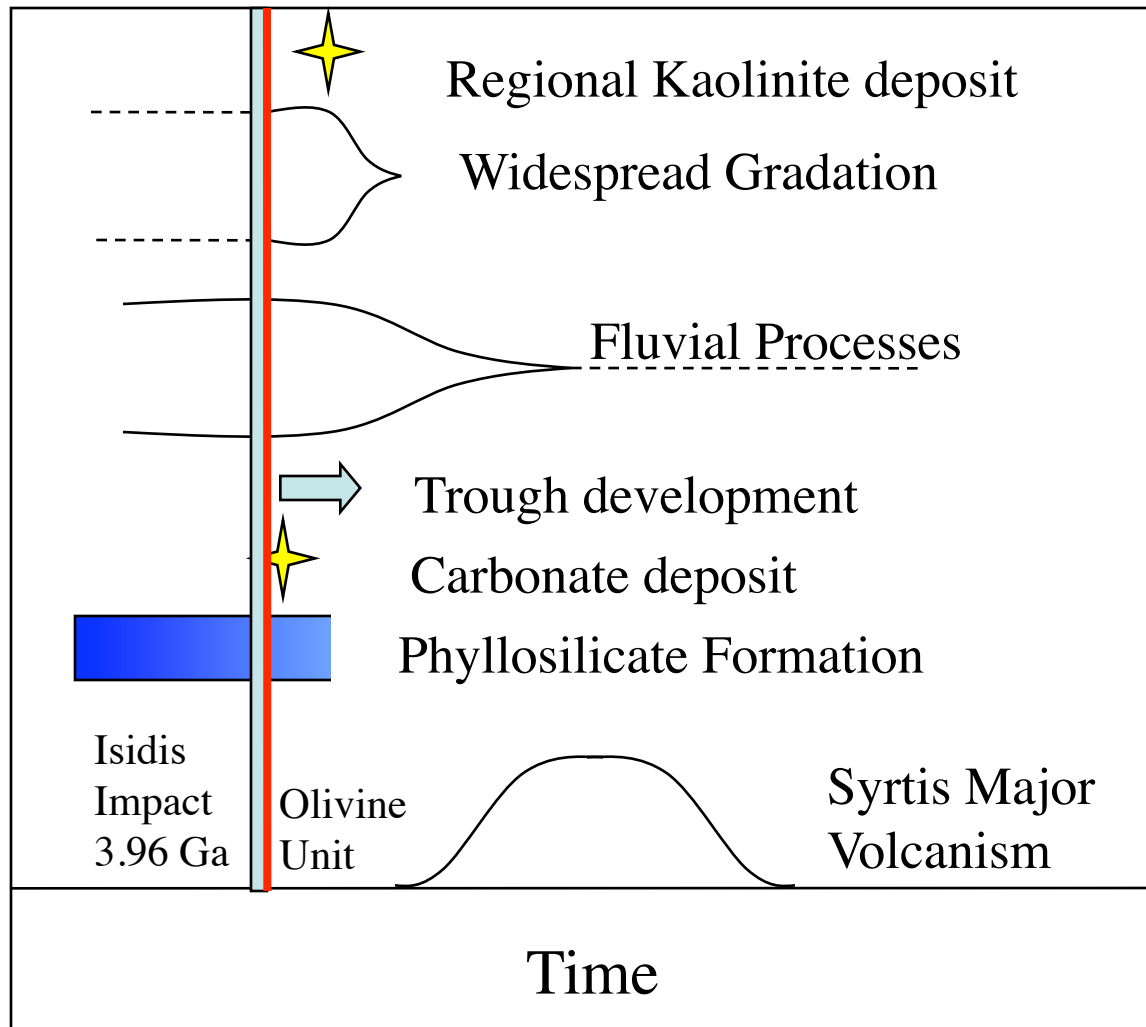
Li-Hung Lin,^{1,2*} Pei-Ling Wang,³ Douglas Rumble,⁴ Johanna Lippmann-Pipke,⁵ Erik Boice,⁶ Lisa M. Pratt,⁶ Barbara Sherwood Lollar,⁷ Eoin L. Brodie,⁸ Terry C. Hazen,⁸ Gary L. Andersen,⁸ Todd Z. DeSantis,⁸ Duane P. Moser,⁹ Dave Kershaw,¹⁰ T. C. Onstott¹

Geochemical, microbiological, and molecular analyses of alkaline saline groundwater at 2.8 kilometers depth in Archaean metabasalt revealed a microbial biome dominated by a single phylotype affiliated with thermophilic sulfate reducers belonging to *Firmicutes*. These sulfate reducers were sustained by geologically produced sulfate and hydrogen at concentrations sufficient to maintain activities for millions of years with no apparent reliance on photosynthetically derived substrates.

Duration of Habitable Conditions

- Fluvio-lacustrine features and location consistent with confluence of long-term regional drainage
- Near-subsurface deposits consistent with widespread evidence of persistent near-subsurface aqueous environments

Stratigraphy and Processes in Isidis-Nili Fossae

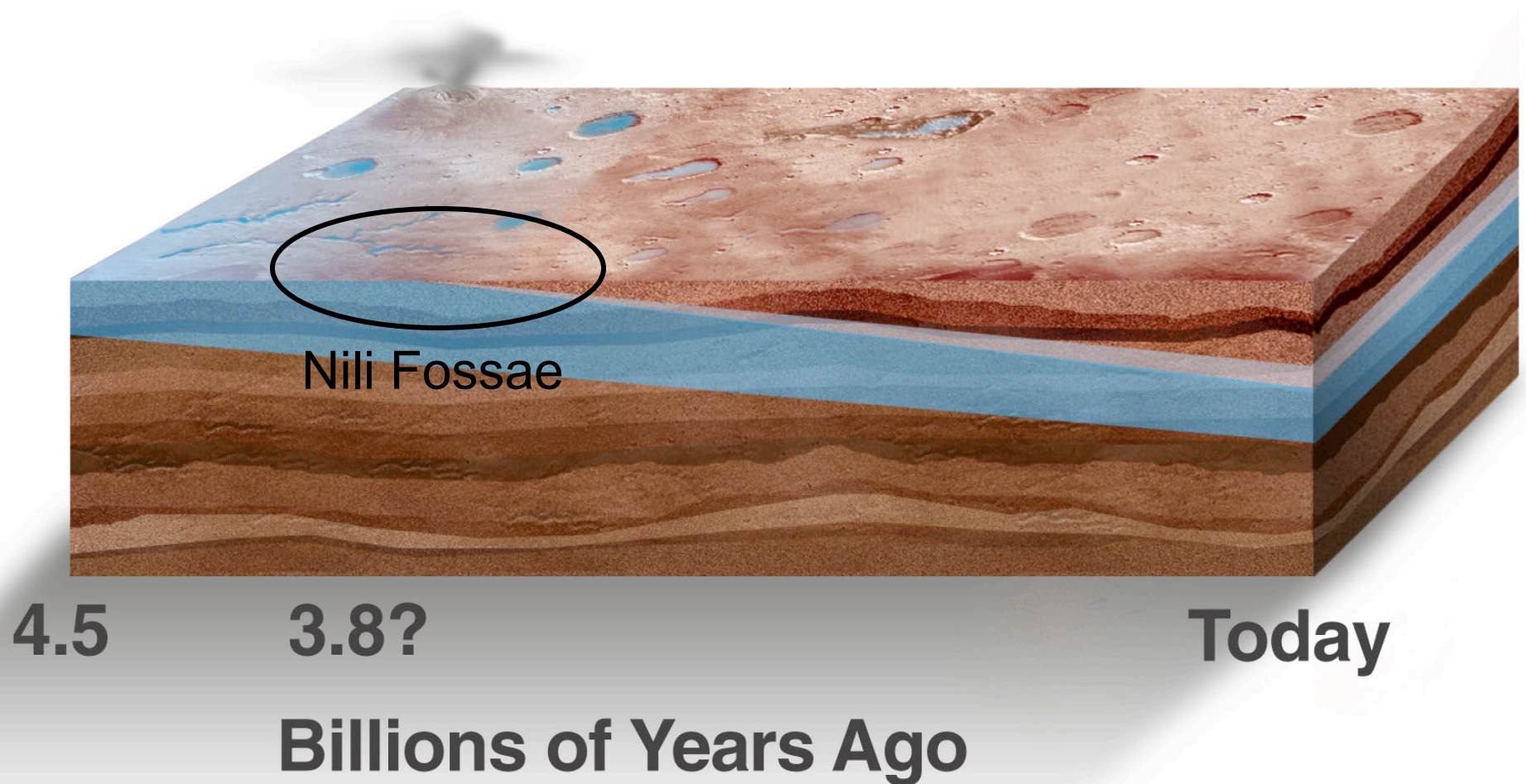


Isidis Basin and Syrtis
Major lavas are major
time-stratigraphic markers

Significant gradation
(sedimentary? aeolian?
alluvial?) between Isidis
basin formation and Syrtis
lava emplacement

How does this constrain
habitability?

Conditions That Could Sustain Life on Mars: Changes Over the Eons

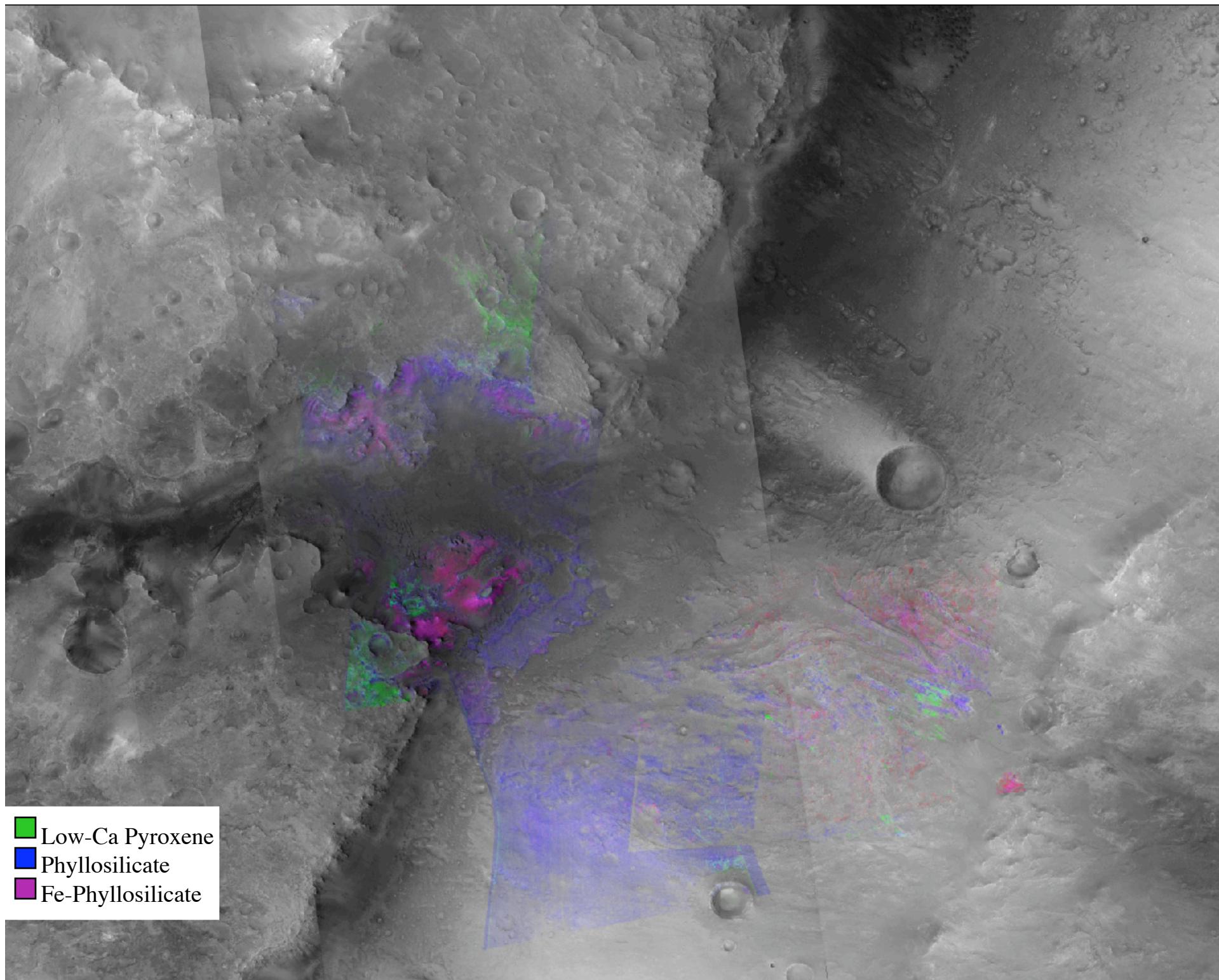


Preservation of Key Evidence

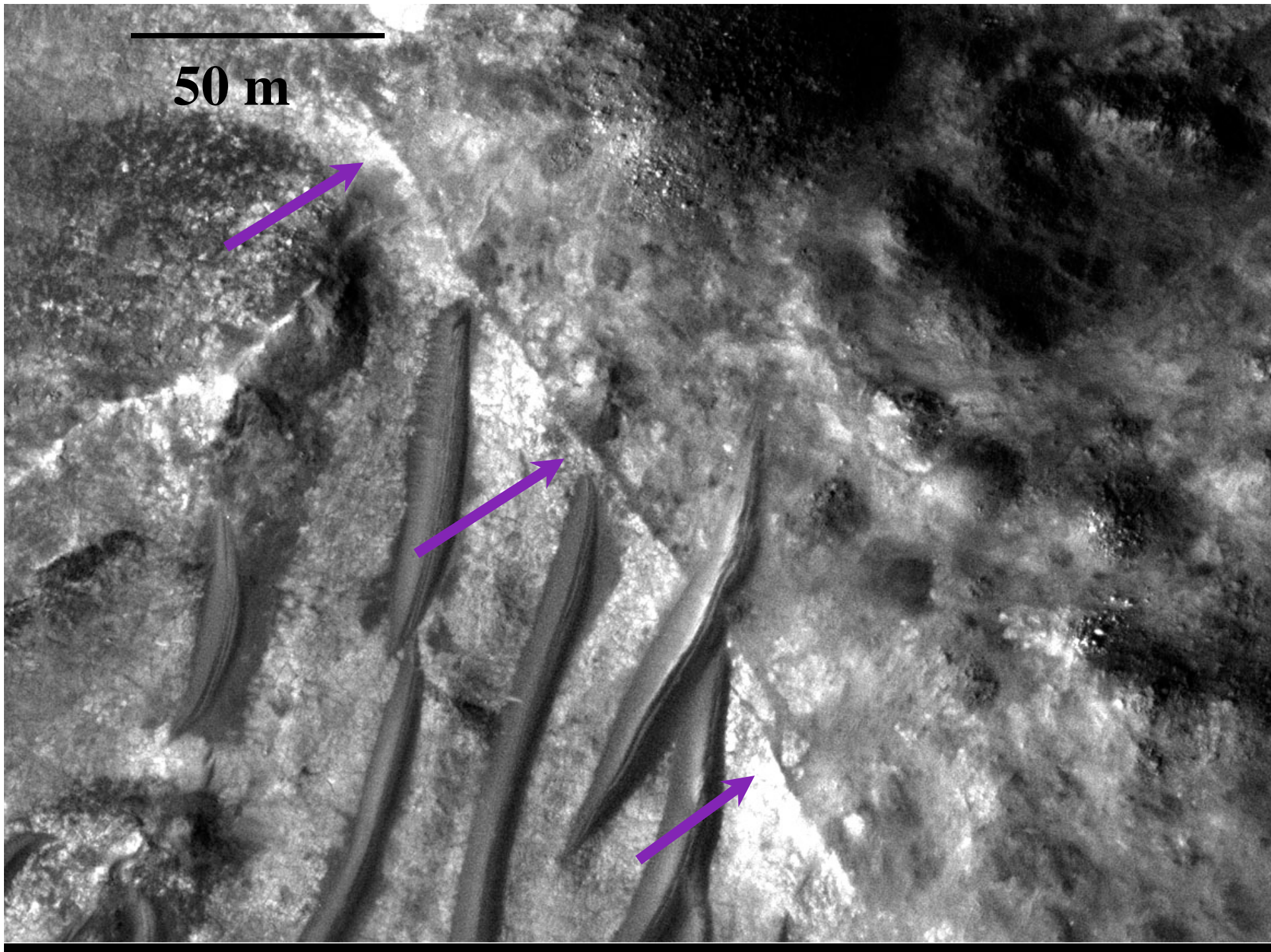
- Primary productivity: higher is better; but on Earth, oxygenic photosynthesis is major factor
- Protection from destructive agents is critical
 - Organisms, thermal, oxidation
- Preservation enhancers
 - Reducing conditions
 - Sequestration in phyllosilicates, silica, carbonates, evaporites, etc.
 - Burial

Minerals & Rocks that Preserve Fossil Records

Residence Time	Least Stable	Dominant Process Controlling Loss
$<1 \times 10^4$ yrs	Ice	Climatic warming
$<1 \times 10^6$ yrs	Halides, sulfates	Dissolution
$<2 \times 10^8$ yrs	Metallic sulfides	Oxidation
$<3.5 \times 10^8$ yrs	Clay-rich shales Water-laid pyroclastics Marine carbonates Metallic oxides	Metamorphism Recrystallization Dissolution
$<3.8 \times 10^8$ yrs	Phosphates Silica	Deep burial Recrystallization Metamorphism
	Most Stable	



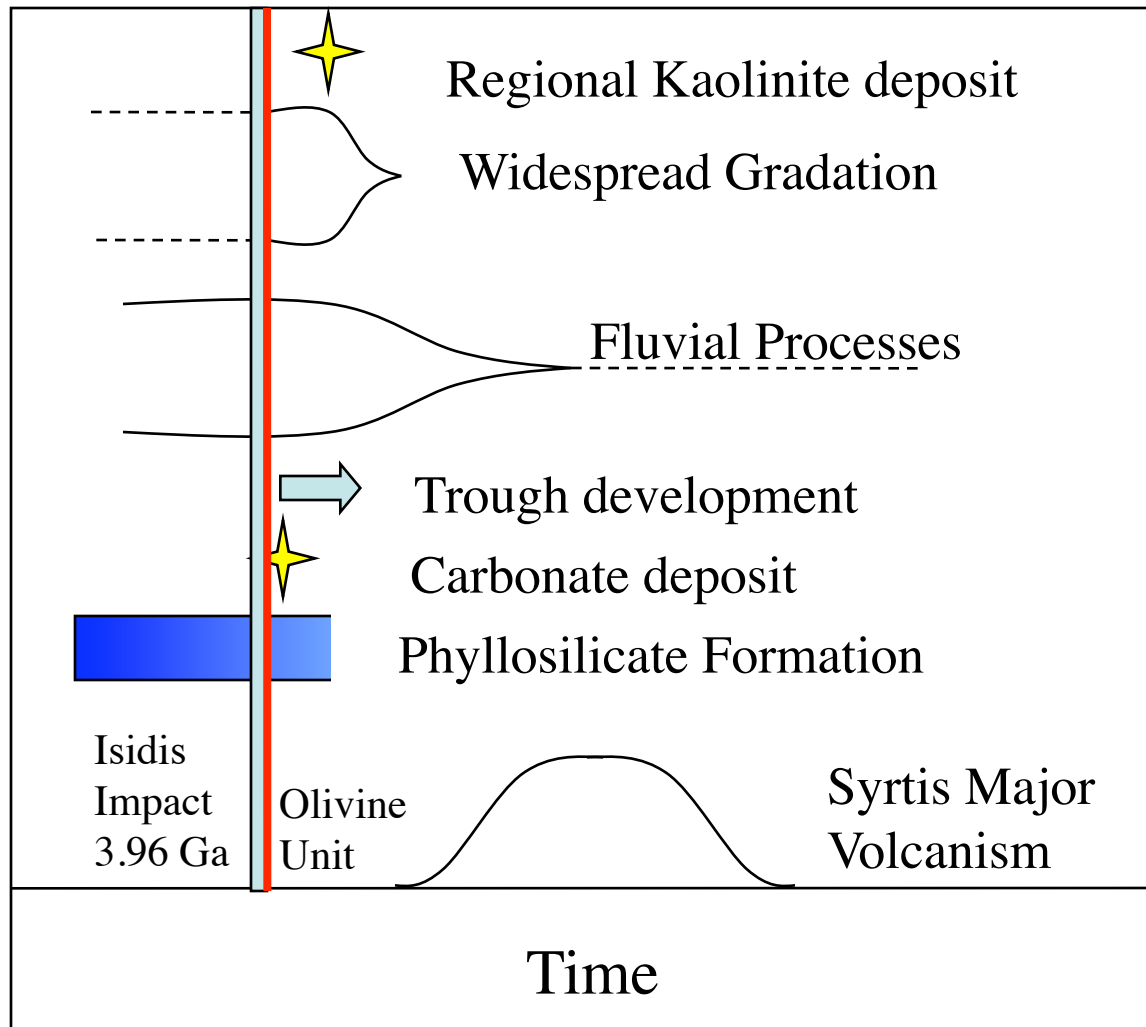
50 m



Access to Key Geologic Units

- Accessible terrane
- Exhumed subsurface deposits
- Fluvio-lacustrine deposits
- Relatively unaltered by weathering

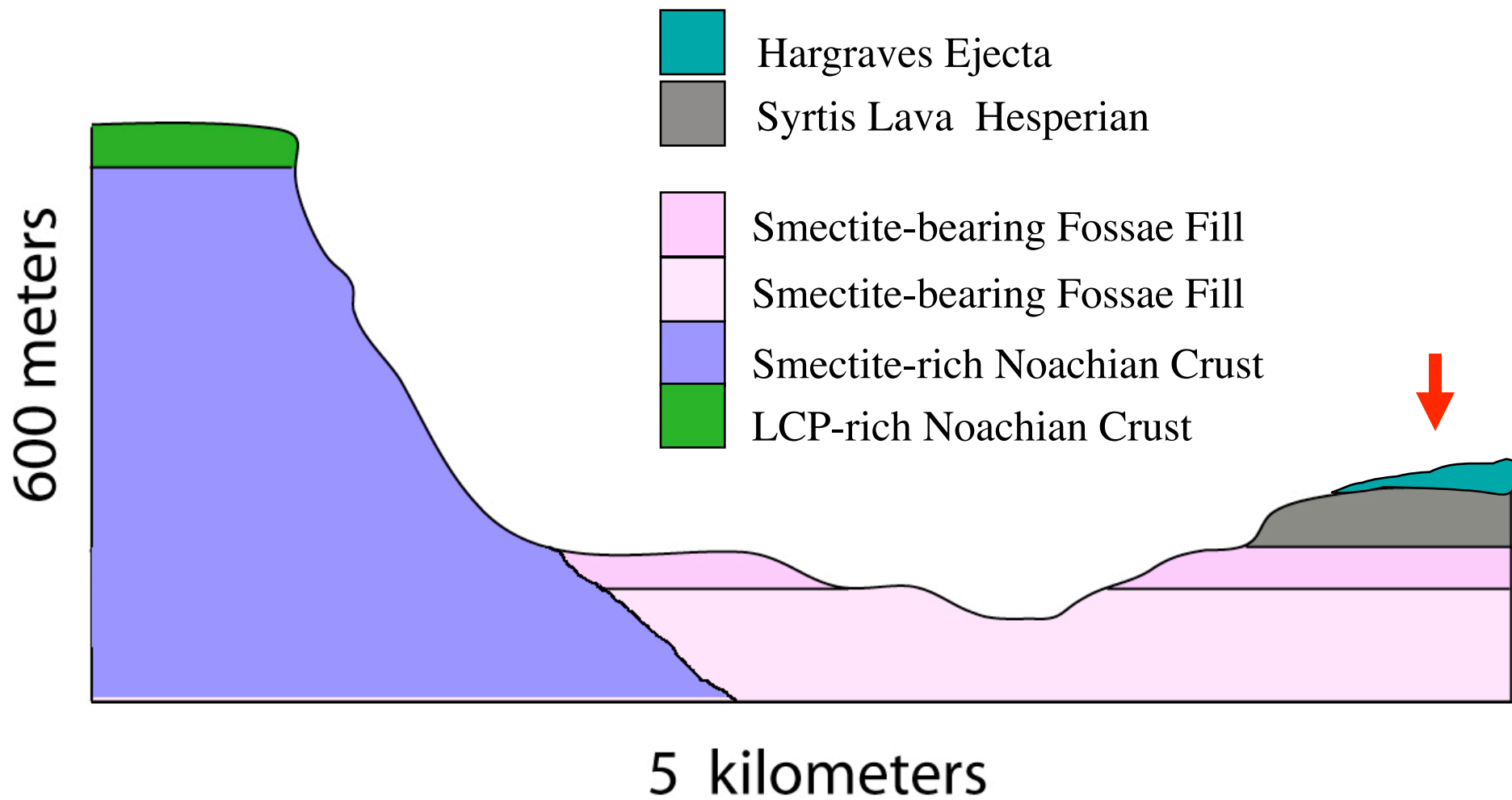
Stratigraphy and Processes in Isidis-Nili Fossae



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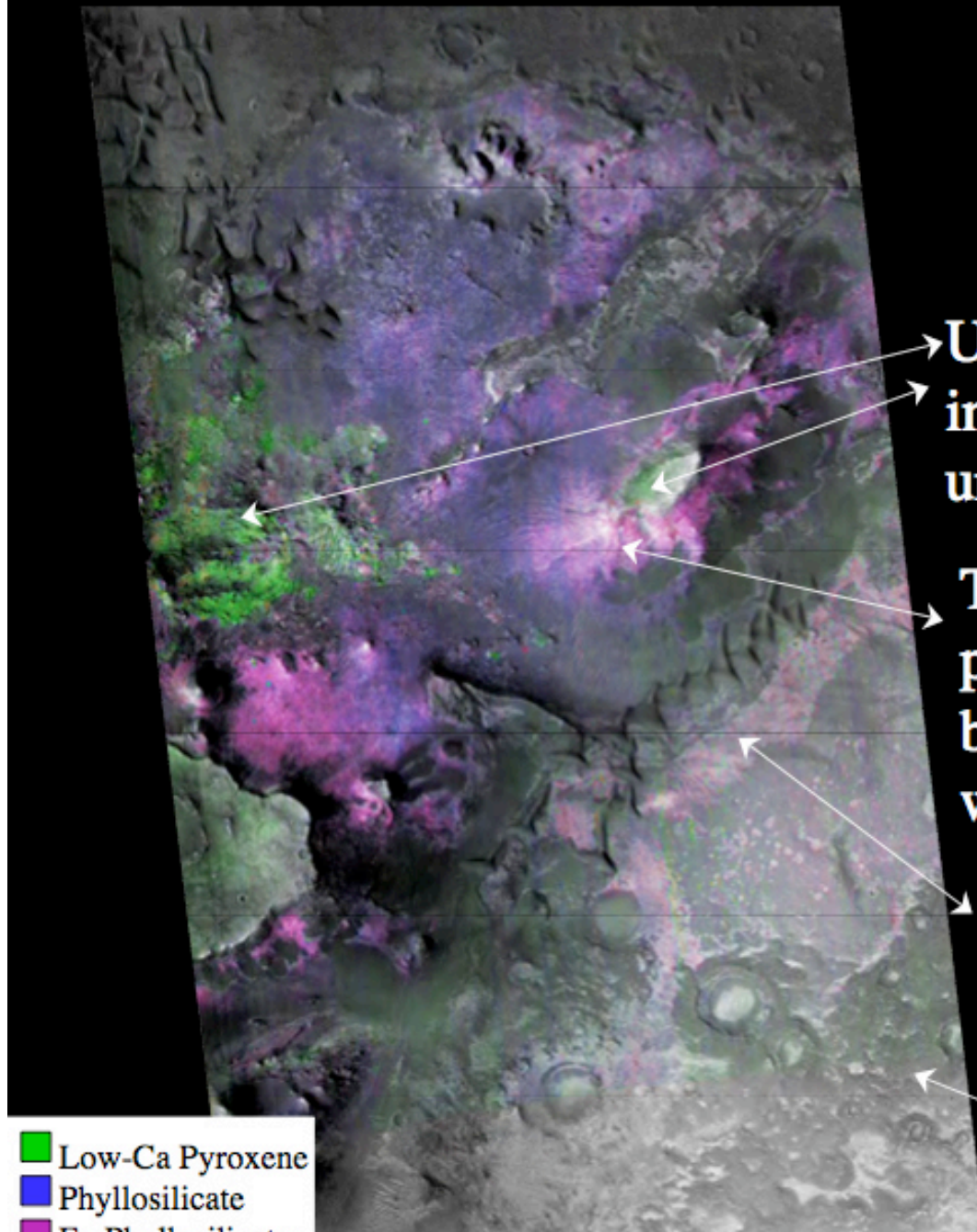
How does this constrain
habitability?



(Representative vertical and horizontal distances, not to scale)

Nili Fossae, Mars

MRO CRISM VIS/NIR
J. Mustard, et al., 2007



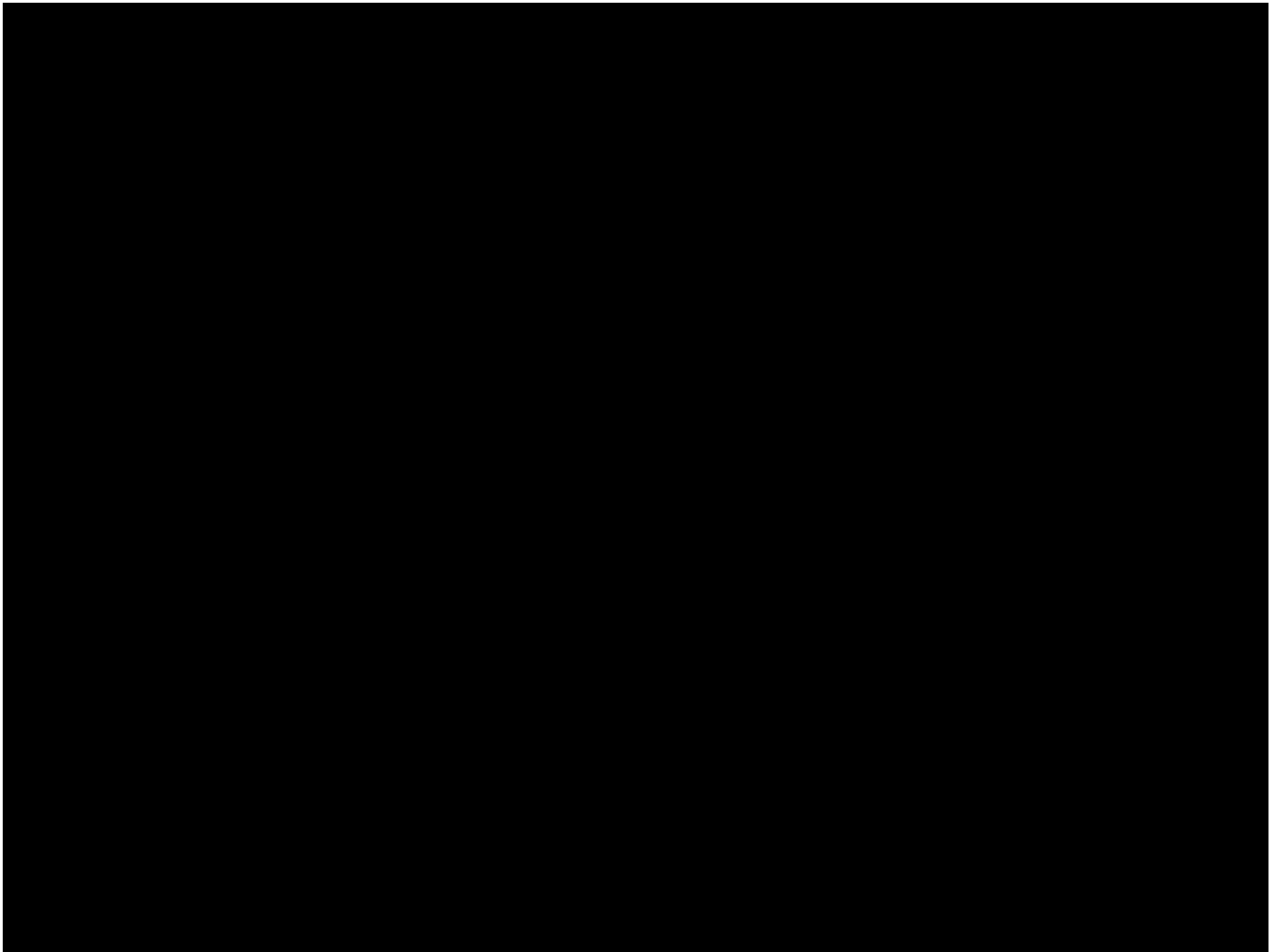
→ Unaltered basement enriched
in low-Ca pyroxene as capping
unit and on the floor

→ Thick section of
phyllosilicate-rich Noachian
basement exposed in Fossae
walls

→ Phyllosilicate-bearing
basement beneath volcanics

→ Syrtis Major Volcanics

■ Low-Ca Pyroxene
■ Phyllosilicate
■ Fe-Phyllosilicate



Microbial Communities in Hypersaline Environments

